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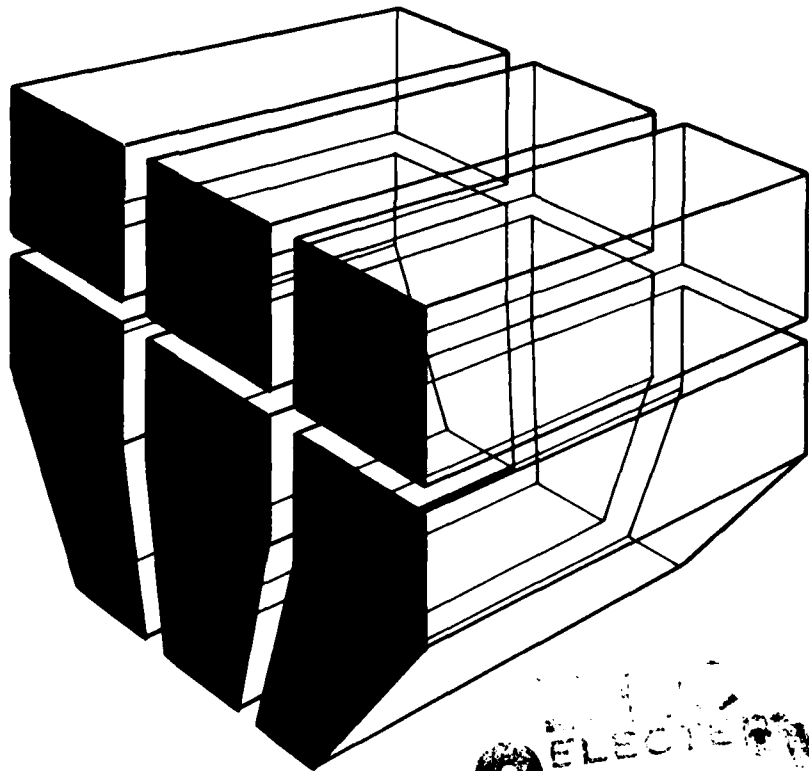
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December 1984

**CORROSION AND COATINGS REVIEW OF SPECIFICATIONS AND
DRAWINGS OF FACILITIES FOR THE OMAN MILITARY CONSTRUCTION PROGRAM
AT MASIRAH ISLAND, OMAN**

by
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struction. Work toward this task is reported, with recommendations based on specifications and drawings submitted by the Corps of Engineers Middle East Division-Winchester. While this information is useful to most interested readers, maximum benefit is obtained when this report is used in conjunction with the specifications and drawings for the military construction program at Masirah Island, Oman.

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FOREWORD

This review was conducted by the U.S. Army Construction Engineering Research Laboratory (USA-CERL) for the Middle East Division-Winchester, under Intra Army Reimbursable Order E87830124, dated 4 May 83. E. Wise, MEDED-MR, was the Technical Monitor.

The work was performed by USA-CERL's Engineering and Materials Division (EM). Dr. R. Quattrone is Chief of EM.

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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CORROSION AND COATINGS REVIEW OF SPECIFICATIONS AND DRAWINGS
OF FACILITIES FOR THE OMAN MILITARY CONSTRUCTION PROGRAM AT
MASIRAH ISLAND, OMAN

1 INTRODUCTION

Background

Environmental conditions in the Middle East (Saudi Arabia, Oman, and Egypt) are quite different from those typical in the United States. The desert sand, wind, and warm, salt-laden air create an environment corrosive to even the most durable materials and coatings. The corrosivity of the environment, coupled with unique operation and maintenance problems, can cause many premature corrosion failures--a critical consideration for U.S. military construction in the Middle East.

Objective

The objective of this report is to review existing specifications and drawings for Middle East construction and to evaluate corrosion and coatings problems specific to the Oman Military Construction Program at Masirah Island, Oman. This work will form the basis for recommending additions and changes to the specifications and drawings, which would apply to all similar environments.*

Approach

The review included (1) evaluation of atmospheric, underground, and seawater corrosivity at Masirah Island; (2) evaluation of corrosion control (cathodic protection, material selection) and coatings systems that have been specified for facilities components; (3) consideration of additional or alternative corrosion control measures or coatings needed since most of the current construction has been completed or is near completion; and (4) recommendations to include lessons learned from previous Corps of Engineers construction work in Saudi Arabia.

Scope

This report covers a review of and recommendations to the specifications and drawings provided by the Corps Middle East Division-Winchester and excludes any site visit comments. These comments will be covered in a future

*Information in this report refers directly to specific sections and pages of the specifications and drawings for the Masirah Island Military Construction Program. Therefore, the reader will obtain maximum benefit when using this report in conjunction with specifications and drawings for the particular job.

U.S. Army Construction Engineering Research Laboratory (USA-CERL) Special Report.

Organization

The report is divided into two major sections: (1) recommendations and comments on the specifications and drawings for the FY81 and FY82 program and (2) recommendations and comments on the specifications and drawings for the FY83 program. Each major section is subdivided into three basic parts: (1) items requiring immediate attention, (2) items to consider for future construction and maintenance needs, and (3) suggestions for the maintenance or rehabilitation of deteriorating items or structures already in place. All recommendations and comments on the specifications are presented in the same order as the specifications provided to USA-CERL (FY81-FY82 Program Specifications for Contract #DACA78-81-C-0207; FY83 Program Specifications for Request for Proposal #DACA78-83-R-0003 dated November 1982)--section and page numbers are followed by the paragraph number. All recommendations and comments on the drawings are presented in order of their Med File number. The Med File number and title of the drawing, followed by the SHT REF number, also are given.

2 SUMMARY OF ENVIRONMENTAL CONDITIONS AT MASIRAH ISLAND

Soil Resistivity

Values for the soil resistivity at this location are not readily available. It is, however, considered to be a very aggressive soil with high amounts of chlorides and sulfates, which can be converted to corrosive sulfides. Soil samples will be taken for analysis during the site visit survey and the results given in a future USA-CERL Special Report.

Temperature

Air temperatures at Masirah Island typically range between approximately 59°F and 104°F with a yearly mean value of approximately 78.8°F.

Relative Humidity and Rainfall

Relative humidities are typically high with a mean average yearly value of approximately 70 percent. Total annual rainfall is usually less than 1 in.

Wind

Winds are frequent at Masirah Island, reaching maximum values of between 25 and 60 miles per hour at least once during a given month.

3 GENERAL REVIEW COMMENTS AND CONSIDERATIONS

The comments and recommendations in this chapter resulted from reviewing the specifications and drawings of facilities being constructed at Masirah Island, Oman. Most information applies to construction at any site with similar environmental conditions. Also, most of this information is described in greater detail in Chapters 4 and 5.

Underground Piping

Protecting underground pipes is a major concern because of the extremely corrosive soil at this location. Ideally, all ferrous piping should be coated and cathodically protected. The adequacy of polyethylene encasement is being evaluated for the corrosion protection of ferrous (including ductile and gray cast iron) piping due to conflicting data in the literature. (See comments in the following chapters regarding specification sections 01003 and 15201.)

Anchors for Buried POL Drain Tanks

Military specification MIL-T-52777 for fiberglass reinforced plastic underground storage tanks specifies corrosion-resistant materials for the tank and hold-down straps. The specification fails, however, to specify acceptable materials for the strap anchor bolts or fasteners. If galvanized hardware is used as specified in the drawings, it should be cathodically protected by attaching a magnesium anode. This is especially important for drain tanks installed in locations with a high water table. (See comments about drawings OM-292 and OM-310 in Chapter 4.)

Exterior Galvanized Steel

All exterior galvanized steel must be coated. If left unprotected, the galvanizing will be consumed rapidly. The protection afforded by a combined coated and galvanized system is considered greater than the sum of the protection afforded from each individual coating system. The one drawback with this system is that not all coatings are compatible with galvanizing. Therefore, a suitable coating system must be selected. (Further details are in the following chapters.)

CORTEN Steel

CORTEN steel should not be specified for facility construction in this type of environment. This steel forms its protective oxide layer only when subjected to environmental air pollutants (particularly sulfides) combined with wet and dry cycles. Without these conditions, CORTEN steel corrodes at the same rate as mild steel. Any existing CORTEN steel construction must therefore be coated. (See comments about specification section 11225 in Chapter 4.)

Use of Oil-Containing Coatings Over Masonry

Oil-containing (oil-based) coatings should not be used over concrete or other masonry-type materials, especially if in a location that will be damp or exposed to water vapor. Water and alkali in the masonry material can react with the oil in the coating, which converts the oil into a "soap." Latex coatings, which are generally alkali-resistant, should be used. Epoxy or chlorinated rubber coatings can also be used as needed. (See comments on specification section 09900 in the following chapters.)

Dissimilar Metal

Dissimilar metal contact should be avoided when possible. If contact cannot be avoided, the dissimilar metals should be isolated electrically using proper gaskets. (See comments throughout the following chapters.)

Metallic Fasteners

When possible, use metallic fasteners of the same or slightly more noble material as the parts being fastened.

Fiberglass Ladders, Gratings, and Doors

Fiberglass reinforced plastic ladders, floor gratings, walkways, manhole covers, doors, etc., for exterior exposure (or interior high-salt-level exposures) should be used wherever possible. Items for exterior exposures must be suitably formulated or coated to protect against ultraviolet (UV) degradation. Ladders, floor gratings, walkways, and manhole covers must be coated with a material that can withstand the UV exposure and personnel foot traffic. Fiberglass items may have a higher initial cost but should prove more cost-effective in the long run due to lower maintenance needs. (See comments throughout the following chapters.)

Grounding Rods and Grids

All copper grounding grids should be cathodically protected when the copper-to-earth potential is more positive than -0.25 V for most soils. Routine potential checks should be performed on all grounding grids and rods in addition to verifying proper grounding resistance. (See comments about specification sections 02711 and 16402 in the following chapters.)

4 DETAILED REVIEW COMMENTS FOR FY81 AND FY82 PROGRAM

Items Requiring Immediate Attention

Certain items requiring immediate attention were noted during the review. Immediate attention may mean immediate correction or changes should be performed to avert catastrophic failure or to eliminate a potential safety hazard; or it may mean careful monitoring of a material's performance when used in a particular item or structure if that information is questionable or unknown. Items addressed here should be considered for any future construction at this site or at any site with similar environmental conditions.

Specifications

01003 DESIGN REQUIREMENTS

01003-26 6.9 Corrosion Protection:

All underground metallic piping shall be coated and cathodically protected. Any unwelded joints in piping shall be bonded for electrical continuity. Revised (Nov 1982) Corps of Engineers Guide Specifications (CEGS)-16650, Cathodic Protection System (Sacrificial Anode), or CEGS-16642, Cathodic Protection System (Impressed Current), should be used. Furthermore, ceramic anodes with performance equal to or better than silicon-iron can be used in impressed current cathodic protection systems. APS Materials Inc., 153 Walbrook Avenue, Dayton, OH, is the exclusive, licensed supplier of the ceramic anode to the Department of the Army (DA).

Polyethylene encasement, as specified, is considered acceptable by the American Water Works Association (AWWA) for gray and ductile cast-iron piping only and not for other buried pipe materials. Slip-on encasements used for the other metallic piping may actually accelerate corrosion, which cannot be stopped effectively with cathodic protection. AWWA states the polyethylene encasement is beneficial for cast-iron piping in corrosive soils. However, the adequacy of polyethylene encasement for the corrosion protection of ferrous piping is still being evaluated due to conflicting data in the literature. Water can leak in between the pipe and encasement, causing corrosion. Once the oxygen is consumed, the corrosion is expected to stop; however, conditions are now perfect for anaerobic bacteria to destroy the pipe. With thick-walled cast iron, this situation can go undetected because a graphite skeleton will be present even after the iron dissolves. The situation can be critical, however, because the pipe would have no strength left and could not withstand a surge of pressure. Future attempts to provide cathodic protection then fail due to the presence of the encasement.

All buried metallic piping or conduits, except copper, should be coated with coal tar enamel or tape meeting AWWA C-203; factory-applied and bonded polyethylene, or factory-applied epoxy coatings (Federal Specification L-C-530, Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy). All field

joints, valves, and similar items should be wrapped with hot-applied coal-tar tape as per AWWA C-203.

Note: hot-applied coal-tar tape that meets AWWA C-203 is considered better than cold-applied protective tapes. However, performance of the hot-applied tape is very dependent on proper application. If there is concern about the quality of labor available, the next best choice is a prefabricated cold-applied tape, 50 mils thick, meeting AWWA C-209. Tapecoat CT-10/40W, made by the Tapecoat Company, Evanston, IL, meets these requirements. Tape wrap should be applied with care because high winds can blow sand onto primer, embedding sand between tape and pipe.

All underground metallic piping should be cathodically protected in addition to being coated. Polyethylene-coated pipe (or the polyethylene encasement sleeves) must be protected from prolonged exposure to sunlight. Also, all bituminous-coated piping and tanks must be covered before burial to limit UV exposure which can quickly deteriorate the protective coating. As polyethylene-encased pipe fails, the replacement pipe sections shall be cathodically protected with a properly sized anode.

02711 FENCE, CHAIN-LINK

02711-6 4.0 Grounding:

Ground rod-to-soil potential should be surveyed routinely to determine where, if any, active corrosion of underground copper is taking place. This is in addition to the routine ground resistance measurements. The "Manual on Underground Corrosion in Rural Electric Systems," Rural Electrification Administration (USDA) Bulletin 161-23, October 1977, shows the correlation between copper tube-to-soil potential and the underground corrosion activity of copper for most soils (summarized in Table 1).

Table 1

Copper Tube-to-Soil Potential and Underground Corrosion Activity

<u>Potential (Volt vs Cu-CuSO₄ Half Cell)</u>	<u>Corrosion Activity</u>
-0.5 or more negative	Copper is well protected; suggests that the copper is cathodically protected
-.025 or more negative	No corrosion in most soils
-0.1 or less negative	May be corroding
0.0 or positive	Probably corroding

05500 MISCELLANEOUS METAL

All galvanized steel with exterior exposure should be coated to prevent the rapid consumption of zinc galvanizing.

05500-4 3.0 Dissimilar Materials:

Dissimilar metal contact should be avoided. If contact cannot be avoided, an electrically isolating gasket should be placed between the dissimilar metals.

05500-8 15.1 General (Manholes, Manhole Covers):

Dissimilar metal contact should be avoided. If contact cannot be avoided, an electrically isolating gasket should be placed between the dissimilar metals.

05500-8 15.2 POL Storage and Distribution:

See comments in 05500-8 15.1.

07600 SHEET METAL WORK, GENERAL

07600-7 4.7 Fastening Materials:

Dissimilar metal contact should be avoided. If contact cannot be avoided, an electrically isolating gasket should be placed between the dissimilar metals.

09900 PAINTING, GENERAL

09900-11 6.7 Plaster Surfaces:

As per CEGS-09910, Painting, General, January 1978, plaster shall be allowed to age at least 30 days before painting. This requirement should be added to future contracts. The aging process decreases surface alkalinity by reaction with carbon dioxide in the air. This, in turn, decreases the chance of paint problems caused by too high surface alkalinity. Problems that occur because of materials already applied should be handled on a case-by-case basis.

11225 WATER DESAL PLANT

11225-13 8.14 Materials (Miscellaneous Metal):

CORTEN steel was specified for the nonstructural part of the desalination plant. The use of CORTEN steel in this environment should be discouraged since it will corrode at the same rate as mild steel. If CORTEN has already been used, the surface shall be sandblasted and coated with an inorganic zinc-rich primer, then topcoated with a vinyl coating system. Note that inorganic zinc primers can be hard to topcoat because primer-topcoat adhesion can

be very poor. Therefore, a proven compatible system of primer and topcoats must be used and specified as such. Preferably, the primer and topcoats should be made by the same manufacturer.

13602 METAL BUILDINGS

13602-17 10.0 Factory Color Finish:

The specifications for the factory-finished wall and roof panels require a minimum dry film thickness of 0.8 mil. For a hot, coastal exposure like Masirah Island, a minimum coating thickness of 3 mils would be more suitable. The installed siding's performance should be monitored very carefully. At the first signs of corrosion attack, the siding and roofing panels should be recoated with an silicone alkyd enamel, a vinyl coating, or other factory-recommended coating compatible with the original factory finish.

15201 WATER LINES

15201-5 2.0 General Comment:

All underground metallic piping shall be coated and cathodically protected. All unwelded joints shall be bonded for electrical continuity. Revised (Nov 1982) CEGS-16650, Cathodic Protection System (Sacrificial Anode), or CEGS-16642, Cathodic Protection System (Impressed Current), should be used. Furthermore, ceramic anodes with performance equal to or better than silicon-iron can be used in impressed current cathodic protection systems. APS Material Inc., 153 Walbrook Avenue, Dayton, OH, is the exclusive, licensed supplier of the ceramic anode to the DA. Polyethylene encasement, as specified, is considered acceptable by the AWWA for gray and ductile cast-iron piping only and not for other buried pipe materials. A slip-on encasement used with the other metallic piping may actually accelerate corrosion, which cannot be stopped effectively with cathodic protection. AWWA states the polyethylene encasement is beneficial for cast-iron piping in corrosive soils. However, the adequacy of polyethylene encasement for the corrosion protection of ferrous piping is still being evaluated due to conflicting data in the literature. Water can leak in between the pipe and encasement, causing corrosion. The corrosion is expected to stop once the oxygen is consumed; however, conditions are now perfect for anaerobic bacteria to destroy the pipe. With thick-walled cast iron, this situation can go undetected because a graphite skeleton will be present even after the iron dissolves. The situation can be critical, however, because the pipe would have no strength left and could not withstand a surge of pressure. Future attempts to provide cathodic protection would then fail due to the presence of the encasement.

All buried metallic piping or conduits, except copper, should be coated with coal-tar enamel or tape meeting AWWA C-203; factory-applied and bonded polyethylene, or factory-applied epoxy coatings (Federal Specification L-C-530, Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy). All field joints, valves, and similar items should be wrapped with hot-applied coal-tar tape as per AWWA C-203.

Note: Hot-applied coal-tar tape meeting AWWA C-203 is considered better than cold-applied protective tapes. However, the performance of the hot-applied tape is very dependent on proper application. If there is concern for the quality of the labor available, the next best choice is a prefabricated cold-applied tape, 50 mils thick, meeting AWWA C-209. Tapecoat CT-10/40W, made by the Tapecoat Company, Evanston, IL, is one tape meeting AWWA C-209. Tape wrap should be applied with care because high winds can blow sand onto primer, embedding sand between the tape and pipe.

Polyethylene-coated pipe (or the polyethylene encasement sleeves) must be protected from prolonged exposure to sunlight. Also, all bituminous-coated piping and tanks must be covered before burial to limit UV exposure which can quickly deteriorate the protective coating. As polyethylene-encased pipe fails, the replacement pipe sections shall be cathodically protected with a properly sized magnesium anode.

15201-12 4.5.5 Valve Encasement:

Valve encasement shall be protected with tape wrap coatings. See additional comments under 15201-5 2.0 General.

15401 PLUMBING, GENERAL PURPOSE

15401-17 14.1 Water Pipe:

Domestic hot water circulating in buildings will be maintained at a maximum temperature of 120°F and a maximum velocity of 5 feet per second to mitigate erosive corrosion of the copper water tubes. If water must be circulated at higher velocities and temperatures, copper alloy 70600 shall be used. The flow velocity limits given above are more restrictive than those specified in TM 5-810-5, Water Supply and Distribution; however, they meet current industry standards. TM 5-810-5 should be revised accordingly.

15401-20 14.6 Protective Coatings for Pipe and Fittings:

See previous comments 15201-5 2.0 General.

15609 POL STORAGE TANKS, CONTROLS, AND PIPING

15609-27 13.4 Grounding Pits:

The 80-inch-long galvanized steel container used to hold the coke breeze in place around the carbon grounding rod will corrode rapidly in aggressive soils. When the pipe deteriorates, the coke breeze may pull away from the carbon rod, causing increased resistance to ground. Therefore, it is especially important to make routine checks of the grounding pits to verify proper grounding resistance. For future construction, a hardened copper container should be used instead of a galvanized steel container. (Also, see previous comments under 02711-6 4.0 Grounding regarding corrosion of underground copper.)

15609-39 21.0 Protective Coatings:

Hot-applied coal-tar tape (AWWA C-203) could be field-applied to unprotected joints and fittings. If a liquid coating is used for field-made joints, it shall be applied in multiple coats to a dry film thickness of at least 8 mils. See previous comments under 01003-26 6.9 Corrosion Protection.

15801 VENTILATING SYSTEM, MECHANICAL

15801-19 13.0 Hoods:

All exposed hoods shall be anodized aluminum or type 304 stainless steel.

16212 GENERATING UNITS, DIESEL-ELECTRIC

16212-74 33. Operating and Maintenance Instructions:

The operation and maintenance instruction manuals supplied with the diesel engine generating system shall include manufacturer's recommendations for make-up water quality and water treatments necessary to mitigate general corrosion in the diesel engine cooling system and cavity corrosion of the cylinder liners. Under no circumstances shall untreated water be used in the cooling system.

16402 ELECTRICAL WORK, INTERIOR

16402-12 7.0 Grounding:

See previous comments under 02711-6 4.0 Grounding.

16532 ELECTRICAL DISTRIBUTION AND STREET-LIGHTING SYSTEM; UNDERGROUND

16532-32 19.0 Grounding:

See previous comments under 02711-6 4.0 Grounding.

16641 CATHODIC PROTECTION SYSTEM FOR STEEL WATER TANKS

16641-6 6.0 Anodes:

The cathodic protection system design for the water storage tanks should be checked with proper water resistivity data. The current required for cathodic protection has been assumed to be 5.0 milliamperes per square foot of total area; however, this is too high for a potable water tank. Instead of 5.0 milliamperes per (total) square foot, 2 milliamperes per square foot of bare area shall be used (assuming a maximum 30 percent bare area). Acceptable alloy materials include platinized or ceramic anodes (APS Materials Inc., 153 Walbrook Avenue, Dayton, OH, is the exclusive, licensed supplier of the

ceramic anode to the DA as well as high-silicon chromium-bearing cast iron (HSCBCI). The new revised specifications, CEGS-16641, November 1982, Cathodic Protection Systems (Steel Water Tanks) shall be used.

16641-7 8.0 Maintenance and Operating Instruction:

Proper rectifier maintenance cannot be overstressed, since this element is usually what fails in a cathodic protection system.

Drawings

OM-158 BAK-13 Standard: (C-120)

The steel used for the buried fairlead tube should be coated and cathodically protected. If uncoated steel has been installed, cathodic protection should be provided by attaching magnesium anodes.

OM-159/OM-160 BAK-13 Standard: (C-121/C-122)

If the anchor bolts used throughout the BAK-13 system are subjected to high humidity and salt deposits, they should be made of either 317 stainless steel or a precipitation-hardened grade of steel such as Armco 17-4PH or its equal. Bolts starting to show corrosion should be coated with coal-tar enamel (MIL-C-18480) or a high-pressure grease. All exteriorly exposed galvanized steel or galvanized steel subjected to high humidity and salt deposits also should be coated.

OM-170 Power Check Pads: (C-132)

Detail A. Galvanized steel exposed to high humidity and salt-laden air should be coated. Also, welding symbols are needed for the rod-to-plate attachment. All uncoated welded areas should be regalvanized or repaired with DOD-P-21035 galvanizing repair paint.

OM-208 Potable Water-Ground Storage Tank: (XM-7)

The galvanized steel hatch cover should be coated. After proper solvent cleaning, a wash primer pretreatment, DOD-P-15328, should be applied first. Compatible vinyl topcoats should then be applied over the wash primer. Choices for topcoats include:

1. VR-3 vinyl coatings as given in AWWA D-102, Outside Paint System No. 2.
2. Vinyl primer MIL-P-15930 followed by vinyl topcoats meeting SSPC No. 9.
3. Vinyl primer MIL-P-15930 followed by Corps of Engineers' specified vinyl topcoats.

OM-214 Saltwater Storage Tank: (XM-13)

The galvanized steel hatch cover should be completely coated. See recommendations for drawing OM-208 above for the proper coating system to use. For new construction or replacement, type 317 stainless steel shall be used.

OM-215 Emergency Water Storage Tank: (XM-14)

The galvanized steel hatch cover should be coated. See recommendations for drawing OM-208 above for the proper coating system to use.

OM-222 Sewer System: (XM-21)

Exposed parts of the galvanized lift bars should be coated.

OM-224 Water and Sewer: (XM-23)

All exterior exposed galvanized steel should be coated.

OM-292/OM-310 POL Storage Drain Tank (Buried): (M-4/M-21)

The drawings specify 0.5-in. galvanized steel hardware embedded in concrete to attach the fiberglass tank holddown straps. Galvanized steel hardware installed without a suitable coating or cathodic protection should now be cathodically protected by digging a manhole and attaching a magnesium anode to each anchor. Otherwise, the galvanized steel loops will fail and, in an area with a high water table, the tank will try to push its way up through the surface. For future construction, all metallic hardware shall be thoroughly encapsulated with a bituminous coating meeting MIL-C-18480. In areas with a high water table, the hardware must be cathodically protected by attaching a magnesium anode in addition to the bituminous coating.

OM-293/OM-351 POL Storage (Grounding Pits)/Hydrant Refueling Pits: (M-5/M-1)

See previous comments about specification section 15609-27 13.4 Grounding Pits.

OM-347 Diesel and Mogas Storage: (S-2)

Galvanized steel ladder rungs exposed to the weather must be coated and maintained.

OM-419 Ammo Storage Igloo: (S-2)

All exterior exposed galvanized steel should be coated.

The material to be used for the air intake pipe must be specified. If mild or galvanized steel was used, it should be coated. Areas where the pipe is welded to the corrugated arch should be repaired with DOD-P-21035, galvanizing repair paint.

Items to Consider for Future Construction and Maintenance Needs

Comments and recommendations in this section should be considered for all future construction at this site or for any other site with similar environmental conditions. This section should also be used as a reference to maintenance criteria in case existing materials fail.

Specifications

01003 DESIGN REQUIREMENTS

01003-2 1.3.1 Small Arms Range:

Doors and Frames. From a corrosion standpoint, all external doors ideally should be made of wood, UV-resistant fiberglass-reinforced plastic (FRP) or anodized aluminum. If steel doors and frames are to be used, they must be factory-zinc-galvanized and primed with a zinc-dust-pigmented primer coating meeting MIL-P-26915. The doors and frames should then be topcoated with two coats of aliphatic urethane meeting MIL-C-83286. (The aliphatic urethane coating, MIL-C-83286, provides excellent UV and abrasion resistance.) Steel doors factory-coated with a red oxide primer should be used only in building interiors or in dry, noncorrosive atmospheric locations such as Thumrait.

01003-4 2.8 Saltwater Intake Structure:

Use copper alloy 70600.¹ An additional FRP intake pipe should be considered as a backup.

01003-11 4.8 Aluminum Screen Doors:

All exterior exposed aluminum should be anodized and not used in conjunction with galvanized steel.

¹Metals Handbook, Ninth Edition, Vol 3 (American Metals Society, 1983) as noted in the Journal of Metals (January 1982).

01003-25 6.5 Floor Drains:

Brass or fiberglass should be used, rather than cast iron, for all grates except the saltwater drain outlet cover.

01003-29 7.5 Telephone Conduit Systems:

For corrosion protection, use hot-applied coal-tar tape or factory epoxy-coated galvanized conduits. Also, see previous comments under 01003-26, 6.9.

02610 RESURFACING RIGID PAVEMENT WITH THIN BONDED RIGID OVERLAYS

The use of seawater for washing aggregate and as mix water must be monitored very carefully during construction. Without proper care, there is potential for significant corrosion of uncoated reinforcing steel. Seawater used as mix water is acceptable in the paving specification if epoxy-coated rebars are used and if the total chloride content of the concrete does not exceed 0.2 percent. Since specifications are different for the concrete placed in different areas, great care must be taken during construction to ensure that only fresh mix water is used with concrete for buildings; similarly, aggregate for building construction should not be washed with seawater. The chloride meter can be used to check the chloride concentration in the concrete mix to ensure it does not exceed 0.2 percent.²

02610-6 5.9 Water:

In the phrase "seawater shall to be used," the word "to" should be eliminated.

02611 CONCRETE PAVEMENT FOR AIRFIELDS

General comment. Epoxy-coated reinforcing bars that conform to ASTM D 3963-81, Epoxy-Coated Reinforcing Steel, should be specified.³

02611-16 6.11 Water:

See previous comments under 02610.

²P. A. Howdysshell, Concrete Quality Monitor: Operations Guide, Technical Report M-293/ADA102753 (USA-CERL, May 1981).

³American Society for Testing and Materials Annual Book of Standards (Philadelphia, PA, 1983).

02618 PAVEMENT MARKINGS (AIRFIELDS AND ROADS)

02618-2 3.2 A Test Report:

Requirements for testing procedures and reports, as given in the last sentence of the paragraph, must be detailed in the specification because Method 1031.2 in the current Federal Standard 141 has been canceled with no superseding document given.

02618-4 6.1.3 Nonreflective Markings:

Correction: "2.50 square meters/liter" should read "2.58 square meters/liter."

02618-4 6.2 Paint:

The following phrase should be added at the end of the first sentence (from CEGS-02577, Pavement Markings (Airfields and Roads)): "and less than 95°F. Paint temperature shall be maintained within these same limits."

The upper temperature limits can be important. A recent failure at Fort Hood, TX, in which the runway paint cracked and lifted, was caused by the paint having been applied thicker than specified and surface temperatures having been greater than 95°F. The lifted paint took 0.25 to 0.5 in. of the underlying asphalt surface with it, making the repairs quite expensive.

For future maintenance work, total accumulation of paint for a marking system should never exceed about four coats before it is totally removed.

02711 FENCE, CHAIN-LINK

With exposure conditions like those on Masirah Island, all fence hardware including fabric, posts, rails, and similar items should be vinyl-coated. For all fencing hardware (posts, rails, gates, etc.), except the fence fabric, specify the following coating system:

1. Zinc galvanizing of 1.0 ± 0.1 oz zinc/sq ft.
2. Polyvinyl chloride coating thermally fused and bonded to a primer which is thermally cured onto the zinc galvanizing. The thickness of the cured polyvinyl chloride coating system shall be a minimum of 0.007 in.

For desert locations, a beige or tan vinyl color fencing would blend into the landscape better than forest green.

For inland locations with dry, noncorrosive atmospheres, the following specifications can be used for the fence hardware:

1. Zinc galvanizing of 1.0 ± 0.1 oz zinc/sq ft.
2. Chromate conversion coating of 30 ± 15 μ g/sq in.

3. Clear cross-linked acrylic polyurethane coating. The thickness of the clear coating shall be a nominal 0.0005 ± 0.0002 in.

(Note: This system is for non-vinyl-coated items. The chromate conversion coating and the clear polyurethane coating should not be specified for vinyl-coated hardware as it may interfere with the vinyl's bonding.)

02711-4 2.4.4 Barbed Wire:

If the galvanized barbed wire must be replaced, stainless steel saw-tooth tape could be used. If reflection of sunlight off the shiny metal would be a problem, the stainless steel can be acid-treated to dull the surface.

03316 CONCRETE (FOR BUILDING CONSTRUCTION)

03316-6 3.4.3 Inserts for Shelf Angles and Bolt Hangers:

Mild steel should be used instead of cast or wrought iron. Cast steel does not have the ductility of mild steel and wrought iron is difficult to obtain.

05120 STRUCTURAL STEEL

05120-1 1.1 Federal Specifications:

TT-P-57 is a discontinued specification, and the cancellation cites TT-P-1757 as a replacement. However, the latter specification is not considered an exact equal for TT-P-57. An alternative, TT-P-645 requires good surface preparation (at least SSPC-SP6) for best performance.

05120-4 3.4 Paint:

The type of paint used can depend on the degree of surface preparation or vice versa (e.g., TT-P-86, Type II performs best with a commercial grade of blast cleaning [SSPC-SP6] whereas Type I is acceptable even with hand-tool cleaning; TT-P-645 should have a surface preparation of at least a commercial grade of blast cleaning [SSPC-SP6] or pickling process cleaning [SSPC-SP8]).

05120-4 4.0 Fabrication:

An additional sentence referring to the section PAINTING, GENERAL for the finish coats should be placed at the end of the paragraph.

05500 MISCELLANEOUS METAL

05500-5 4.1 Aluminum:

All exterior exposed aluminum surfaces shall be anodized and not used in contact with galvanized steel.

05500-7 10.0 Access Doors:

All exposed access doors should be galvanized and painted to retard corrosion.

05500-7 11.0 Control Joints:

Aluminum used in direct contact with concrete is not recommended. If contact cannot be avoided, the anodized aluminum should be back-coated with bituminous coating (MIL-C-18480 or TT-V-51).

05500-7,8 13.0, 14.0 Floor Gratings and Frames, Floor Plates:

Floor gratings, frames, and plates should be brass or fiberglass. Steel is highly corrosive in a seawater environment and any protective paint would soon be worn away by floor traffic. Stainless steel should not be used as it pits quickly in standing seawater.

05500-10 17.0 Ladders:

Interior. The specifications require steel POL tank to be electrically isolated from the aluminum ladder. For additional protection, make sure the steel flanges to which the ladder will be attached are completely coated.

Exterior. FRP ladders should be used whenever possible. Ladders must be coated with a material that can withstand the UV exposure and personnel foot traffic.

05500-11 22.0, 23.0 Safety Chains, Guard Rails, Safety Nosings:

Safety chains, guard rails, and safety nosings should be galvanized steel. Wrought iron is difficult to obtain and provides no benefit over steel.

Guard Rails. Because of required material thicknesses, corrosion of guard rails should not be a major problem. To protect esthetics, however, the guard rails should be given one coat of zinc-dust primer coating (TT-P-641) or zinc-dust chlorinated rubber primer coatings (TT-P-1046). Within 500 ft of the shoreline, TT-P-1046 becomes the better choice. Either coating should be used for future maintenance of galvanizing.

05500-12 25.0 Steel Stairs:

FRP stairs should be used whenever possible. The stairs must be coated with a material that can withstand the UV exposure and personnel foot traffic.

05500-12 27.0 Shop Painting:

Bituminous coatings TT-V-51 or MIL-C-18480 shall not be used when exposure to sunlight is possible because these coating deteriorate very rapidly from UV radiation. Even items with these coatings applied which are to be buried or concealed shall not have prolonged exposure to UV radiation before concealment. If the exposure is to be more than 7 days, the items must be covered with a tarp, opaque plastic, or other protective cover.

07112 ELASTOMERIC WATERPROOFING

07112-3 3.7 Compound Butyl Rubber:

The term "compound butyl rubber" in this context is more correctly termed "compounded butyl rubber."

07112-4 3.7 Compound Butyl Rubber:

ASTM Test Method D-471, Effect of Liquid, is not a test for butyl "identification." Rather, it is a test of rubber properties. The specification requirement is stating that a properly formulated butyl rubber compound should not swell more than 10 percent when immersed in tricresyl phosphate for 70 hr at 212°F.

07463 ROOFING AND SIDING, ASBESTOS CEMENT

07463-3 6.3 Fasteners:

Washers should be of material similar or identical to the fastener.

07600 SHEET METAL WORK, GENERAL

07600-7 4.9.2, 4.9.3 Bird Screen; Frames:

Aluminum screen shall be used with aluminum frames and stainless steel screen shall be used with stainless steel frames. Aluminum and steel should not be mixed. If only aluminum screens are to be used, stainless steel frames should be deleted from the specifications.

07600-9 7.0, 7.1 Protection of Aluminum, Contact Surface:

Aluminum surfaces shall not be in direct contact with concrete. Exterior exposed aluminum surfaces shall be anodized and shall not be used in conjunction with galvanized steel.

07840 VENTILATORS, ROOF; GRAVITY-TYPE

07840-3 6.5, 6.6 Constuction; Screens:

Galvanized steel should not be specified for the construction of ventilation screens in a warm, coastal environment. Anodized aluminum should be specified for both the ventilator and screen to minimize corrosion attack and to avoid dissimilar metal contact.

07951 CALKING AND SEALANTS: GENERAL

1. To obtain a dense layer of sealant, all sealants should be applied beginning at the bottom of the joint crevice and gradually building up to avoid trapped air or voids.
2. Sealant or calking paintability is valuable information and should be included on the label.
3. The manufacturer's recommended solvent should be used for cleaning.

08105 STEEL DOORS AND FRAMES

08105-3 3.7 Thresholds:

"Aluminum" is misspelled as "aluminum."

All exterior exposed aluminum shall be anodized and not used in contact with galvanized steel.

08105-3 3.8 Louvers:

Bronze cloth should not be specified for insect screens in a warm, coastal environment. (The formation of corrosion products severely reduces the cross section of the thin bronze screen wire.) In addition, aluminum screen shall be used in conjunction with aluminum frames only and the frames shall be electrically isolated from the steel door with a nonconductive gasket to avoid dissimilar metal contact.

08105-5 7.0 Installation:

A sentence referring to the section PAINTING, GENERAL for the finish coats should be added to the end of the paragraph.

08300 MISCELLANEOUS DOORS

External doors ideally should be made of wood, UV-resistant FRP, or anodized aluminum. See additional comments under 01003-2, 1.3.1.

09900-2 1.1 Federal Specifications:

On the bottom one-third of the page, TT-P-57B, paint, zinc yellow-iron oxide-based, ready-mixed, and TT-P-105A, painting oil: chalk resistant, lead-free, exterior ready-mixed, white and tints have been canceled. The cancellation notice for TT-P-57 cites TT-P-1757 as a replacement. However, this specification is not considered to be an exact equal for TT-P-57B. TT-P-86, paint, red-lead based, ready-mixed, or TT-P-615, primer coating; basic lead silicon chromate, ready-mixed, can be used instead of TT-P-57B. TT-P-102D, paint, oil alkyd (modified) exterior, fume-resistant, ready-mixed white and tints, can be used instead of TT-P-105A.

09900-8 4.8 International Orange Enamel:

Enamels meeting TT-E-489, colored international orange, may have more than 0.5 percent lead. However, as already stated, any coating with more than 0.5 percent (or even 0.06 percent) lead probably could be used at facilities such as these. The lead laws prohibit the use of leaded coatings only on areas accessible to children, such as family housing.

Consideration should be given to specifying exterior enamel TT-E-1593 instead of TT-E-489. TT-E-1593 (or TT-E-490, semigloss) is a silicone-modified alkyd coating that has better weathering ability and UV resistance than TT-E-489. Although it is more expensive, the TT-E-1593 coating (or TT-E-490, semigloss) should perform better than TT-E-489 in the desert.

09900-8,9 5.0 Quality Assurance Provisions:

The sentence starting at line 3 says: "When certifying a maximum of 0.5 percent lead, the Contractor shall also certify that the paint was manufactured prior to June 23, 1977." For future contracts, this provision should be dropped as the paint would be very old and of questionable quality.

In the sentence starting at line 19, requirements for the testing procedures and reports must be detailed in the specification since Method 1031.2 in the current Federal Standard 14 has been canceled with no superseding document cited.

In the last sentence on the page, the specified "\$100/sample for retesting" is not considered enough. An average of \$250 to \$500 per sample is more in line with current laboratory charges. Since the specification states that the cost of retesting will be deducted from the payments due the contractor, no fixed amount needs to be stated. Costs can vary with time and the laboratory used.

09900-10 6.2 Concrete and Masonry Surfaces:

Concrete surfaces to be painted shall have the surface glaze, if present, removed by light blasting or by scrubbing with a 5 percent solution of phosphoric acid. The acid treatment shall be followed by rinsing the surfaces

08300-3 5.1 General: (Aluminum Screen Door):

All exterior aluminum should be anodized and should not be used in conjunction with galvanized steel.

08300-3 5.4 Protection From Dissimilar Metals:

Aluminum used in direct contact with concrete is not recommended. If contact is unavoidable, the anodized aluminum should be back-coated with bituminous coating, MIL-C-18480 or TT-V-51, or an electrically isolating gasket should be provided.

09900 PAINTING, GENERAL

A definition of a rust-inhibitive coating should be added to the specifications: "Rust-Inhibitive Coating--Coating used for preventing the corrosion of metals and, more particularly, specially formulated to prevent the rusting of iron, steel, and other metals."

Red lead primer, TT-P-86, should be specified for oil-based (enamel) paint systems used to protect mild steel exposed to the atmosphere. However, the lead content of TT-P-86 far exceeds the 0.06 percent maximum required in U.S. Public Law 94-317. Lead-containing paints are prohibited for all child-accessible interior and exterior areas of any school, nursery, or family housing. Under normal circumstances, such paints do not pose a health threat for adults and, therefore, should not be restricted at the type of facilities being constructed at military installations in the Middle East. Alternative non-lead-containing paints are either more expensive due to greater material and labor costs (from the greater surface preparation needed) or have inferior performance, especially for hot, coastal exposures. Red lead primer has even greater value for maintenance painting.

Because temperature can greatly affect the film's application and resulting performance, the following section should be added: "Environmental Conditions--Unless otherwise recommended by the paint manufacturer, the ambient temperature shall be between 45 and 95°F when using water-thinned, epoxy, polyester-epoxy, moisture-cured polyurethane, vinyl, and liquid glaze coatings. Water-thinned coatings will be applied only within the minimum and maximum temperatures recommended by the coating manufacturer or as given elsewhere in the specification. Variance to the stated upper temperature limits will be approved only if it can be demonstrated that the variance will not cause inferior coating performance. Paints, except water-thinned types, shall be applied only to surfaces completely free of surface moisture as determined by sight or touch. In no case shall paint be applied to surfaces on which frost or ice is visible."

with water and allowing to dry. For interior walls and floors, sandblasting, unless specifically authorized otherwise, shall be restricted to the wet or vacuum type.

09900-11 6.7 Plaster Surfaces:

The requirement that plaster shall be allowed to age at least 30 days before painting (as per CEGS-09910, Painting, General, January 1978) should be added to future contracts. The aging process decreases surface alkalinity by reaction with carbon dioxide in the air. This, in turn, decreases the chance of paint problems caused by a too high surface alkalinity.

09900-14 7.8 Epoxy-Polyamide Coating Application:

The sentence, "This coat should be thinned down to 20 to 30 percent" implies that 70 to 80 percent thinner should be added. Assuming that thinning by 20 to 30 percent was originally intended, the sentence should be replaced by: "The coating should be thinned approximately 20 to 30 percent with the manufacturer's recommended thinner. If manufacturer's instructions suggest thinning by some other amount for application of the first (light) coat, those instructions should be followed."

09900-18 Painting Schedule:

Regarding the second system on the page: for greater corrosion protection of non-shop-coated bare steel, specify TT-P-86, Type II, rather than a ferrous metal primer. Power tool cleaning meeting SSPC-SP3 or brush-off blast cleaning meeting SSPC-SP7 is considered minimum surface preparation for using this primer. (Type I primer is acceptable with hand-tool cleaning meeting SSPC-SP2. However, the dry time for the Type I primer is much longer than for the Type II. This may not be advantageous in windy and dusty locations.) Also, for the second and third coats, rather than specifying an exterior oil paint, specify an exterior alkyd-enamel, TT-E-489 (TT-E-529 for semigloss) or an exterior silicone alkyd enamel, TT-E-1593 (TT-E-490 for semigloss) for much greater protection of steel in such these environments. (Also, see comments under 09900-8, 4.8.)

In reference to the third system on the page: for exterior exposures, a rust-inhibiting primer should be specified as the shop-coat primer. Areas where the shop coating has been damaged should be power-tool-cleaned as per SSPC-SP3 or brush-off blast-cleaned as per SSPC-SP7 before applying the TT-P-86, Type II primer. (The above surface preparation choices are considered minimum for the Type II primer.) Also, see above comments on specifying exterior oil paint for the second and third coats.

Regarding the fourth system on the page: although the specified system should not fail catastrophically, it will not provide maximum protection. One of the following systems is recommended for exterior galvanized surfaces:

1. One or two coats (depending on exposure conditions) of zinc-dust primer coating (TT-P-641), or zinc-dust chlorinated rubber primer coating (TT-P-1046).

2. A primer coat of TT-P-641 with two topcoats of exterior alkyd enamel or silicone alkyd enamel (also see comments regarding exterior alkyd enamel under 09900-18, second system on the page, and 09900-8, 4.8.)

3. Two coats of zinc dust primer coating (MIL-P-26915) and two coats of aliphatic urethane topcoat (MIL-C-83286).

For better adhesion over galvanized surfaces, the wash primer pretreatment DOD-P-15328 should be used.

09900-19 Painting Schedule:

Regarding the second and third systems on the page for all interior concrete, plaster, or other masonry surfaces: TT-P-29 latex base paint is sometimes specified as a primer to protect oil-containing topcoats from attack by the alkali in masonry. Actually, too much moisture can still cause a problem. When alkali reacts with the oil in an oil-based coating, the coating becomes soft and slimy, and brownish streaks may run down the walls. The whole mess is not easily remedied. A sure cure is to use a complete "latex" coating system for concrete walls such as:

1. TT-P-29 as primer and topcoat.
2. TT-P-19, exterior acrylic emulsion, as primer and topcoat.
3. TT-P-29 as primer with TT-P-1511, interior latex paint, for topcoating (TT-P-1511, Type I, for semigloss, Type II for gloss).

If needed, a block filler can be used under any of these systems. If a moisture-resistant system is needed, use TT-P-95, chlorinated rubber paint, as primer and topcoat. If a heavy-duty system for a tile-like finish on concrete is needed, use TT-C-535, epoxy coating, as a primer and topcoat.

Regarding the last system on the page, the following note should be added to this system: "A ferrous metal primer shall be selected that is compatible with the specified alkyd enamel second and third coats."

09900-20 Painting Schedule:

Regarding the first system on the page: If less than 50 percent of the total shop-coated area has sustained damage, spot prepare and prime the damaged areas rather than coating the entire surface with the ferrous metal primer. The note should be changed to read: "A ferrous metal primer shall be selected that is compatible with the shop-applied primer and the specified alkyd enamel second and third coats."

09900-21 Painting Schedule:

Regarding the second system on the page: this system should read exactly like the last system shown on page 09900-18 for interior exposed ferrous surfaces. The previous comments regarding the last system on page 09900-18 also apply.

09900-22 Painting Schedule:

Regarding the last system on the page: a heat-resistant paint that will perform better than TT-E-496 in corrosive environments is MIL-P-14105, paint, heat-resisting, (for steel surfaces). This coating is suitable for exposures up to 1400°F.

10160 METAL TOILET PARTITIONS

10160-2 6.0 Installation:

Line 8 of the paragraph states that: "Baked enamel finish shall be touched up with the same type and color of paint." The exact same type of paint should not be used since it requires baking at high temperatures for proper curing. Rather, the manufacturer's recommended touch-up enamel coating should be specified.

10910 SPECIALTY ITEMS

10910-5 6.0, 6.1 Shower Stalls; Walls:

The shower stalls now specified have a poor design due to the dissimilar metal contact. Fiberglass shower stalls shall be specified, especially when brackish water will be used.

11225 WATER DESAL PLANT

11225-8 8.2 Coordination:

All underground steel pipe shall be coated/tape-wrapped and cathodically protected. See additional comments under Items Requiring Immediate Attention, section 01003-26, 6.9.

11225-9 8.3.3 Distillate Produced:

Product water hardness should be specified to a Langelier index* of +0.5 to prevent internal corrosion of pipes by soft water. This value can be reached using a passivator as specified under 11225-14, 8.16.

*Measure of solubility.

11225-10 8.5 Evaporator Condenser:

Monel alloy 400 should be specified for constructing the mist eliminator rather than type 316 stainless steel. This alloy has greater resistance to pitting and stress corrosion.

11225-10 8.6 Brine Heater:

Copper-nickel alloy 70600 (90-10 Cu-Ni 1.5 Fe)⁴ should be specified instead of 90-10 copper nickel alloy.

The use of 90-10 Cu-Ni 1.5 Fe alloy is preferred over 70-30 Cu-Ni 0.5 Fe alloy, especially in plants using acid treatment and maintaining brine heater temperatures close as practical to the scaling temperature (392°F). However, two other factors that must be considered are the presence of pollutants such as dihydrogen sulfide (H₂S) and ammonia (NH₃) and velocity effects.

The 70-30 Cu-Ni 0.5 Fe alloy is preferred over 90-10 Cu-Ni 1.5 Fe alloy for polluted waters and higher velocities. As the seawater velocity increases, the protective film that forms on the brine heater tubes is stripped away. The 70-30 Cu-Ni alloy modified with up to 2 Mn and 2 Fe is preferred when the design velocity is 15 to 20 ft/sec. The iron and manganese aid in reforming the complex protective layer once it is stripped away. The 90-10 Cu-Ni .5 Fe alloy is preferred when the design velocity is 8 to 12 ft/sec. Additional data can be obtained from another reference.⁵

11225-10 8.7 Vacuum Systems:

Type 317L stainless steel should be used instead of type 316L. Type 316LS stainless steel containing approximately 2.2 percent molybdenum is the lowest grade alloy to consider for use in desalination. A rule of thumb for selecting of the proper grade is that it must contain enough chromium and molybdenum that its chromium equivalent exceeds 29.

$$\text{Chromium equivalent} = \% \text{ Cr} + (3.3 \times \% \text{ Mo}).$$

$$\text{Chromium equivalent for 316L} = 18 + (3.3 \times 2.2) = 25.$$

$$\text{Chromium equivalent for 317L} = 19 + (3.3 \times 3.3) = 30.$$

317L is approximately 1.5 times the cost of 316L due to the higher molybdenum and chrome contents and increased corrosion resistance. Additional information is available elsewhere.⁶

⁴Metals Handbook.

⁵B. Todd et al., Desalination--Lower Cost Water by Proper Materials Selection, Third European Symposium on Fresh Water From the Sea, Dubrovnik, Yugoslavia, September 14-17, 1970.

⁶Proceedings of the Second BSE-NACE Corrosion Conference, January 19-21, 1981, Bahrain.

11225-13 8.14 Materials (Miscellaneous Metal):

Pump construction. If the interior surface is exposed to seawater and brine, nickel aluminum bronze shall be used. For an interior surface exposed only to fresh water or condensate, stainless steel type 316 shall be used.

Fiberglass-reinforced walkways and gratings should be used whenever possible. Walkways and gratings must be coated with a material that can withstand the UV radiation and personnel foot traffic.

No stainless steel shall be used in the desalination plant when contact with standing saltwater is possible. No galvanized steel should be used in the desalination plant. When intermittent contact with saltwater is possible, bolts, nuts, anchors, and washers should be phosphor bronze or stainless steel type 316.

Regarding the last sentence of the paragraph: for shop priming, specify two coats of red lead primer, TT-P-86, Type II, rather than two coats of zinc chromate.

11225-15 8.18.6 Painting:

Specify a surface preparation meeting SSPC-SP6 or SSPC-SP10, as needed, instead of sandblasting the items in accordance with coating specification SSPC-16-68T. Also, if the boiler and surrounding steel will exceed 250°F, special coatings will be needed; do not use a regular steel primer as specified. For interior or mild exterior exposure, use TT-E-496, enamel, heat-resisting (400°F), or TT-P-28, paint, aluminum, heat-resisting (1200°F). For exterior, corrosive exposures, use MIL-P-14105, paint, heat-resisting (for steel surfaces) (1400°F).

If the system starts to fail because of extreme temperatures, all paint must be removed by sandblasting, preferably to a near-white metal grade, SSPC-SP10, and coated as stated above.

11225-20 8.26 Fuel Oil Tank:

The exterior surface for the desalination boiler tank should be sandblasted to near-white metal grade, SSPC SP10, primed with an inorganic, zinc-rich coating, and topcoated with a vinyl coating system. See the previous comments on inorganic zinc-rich coatings under Items Requiring Immediate Attention, section 11225-13, 8.14.

As a minimum, the tank should be sandblasted to a commercial grade, SSPC-SP6, primed with a red-lead primer, TT-P-86, Type II, and topcoated with alkyd enamel TT-E-489 or silicone alkyd enamel TT-E-1593. TT-E-529 and TT-E-490 are the respective semigloss versions of the coatings previously listed. See also comments under 09900-8, 4.8.

Fuel-oil tank interiors should be fitted with a splash impingement platform below the fill line to minimize localized erosion corrosion.

11225-20 8.28 Seawater Feed Pumps:

Eliminate bronze and type 316 stainless steel; use only nickel-aluminum-bronze.

11225-21 8.29 Installation:

All ferrous underground metal piping, including stainless steel, shall be tape-wrapped or coated, then cathodically protected. Also, see previous comments under Items Requiring Immediate Attention, 01003-26 6.9, Corrosion Protection.

13602 METAL BUILDING

13602-8,9 7.3, 7.4, 7.5 Exterior Wall, Accessories, Fasteners:

Use of dissimilar metals should be discouraged. All exterior exposed aluminum should be anodized and not used in conjunction with galvanized steel.

13602-17 8.14.1 Before Shipment (Straight Slide Hanger Doors):

The specification calls for "one sprayed-on coat of top quality zinc oxide primer." However, zinc oxide is not an inhibitive pigment and has little value in a metal primer. A red-lead primer, TT-P-86, should be specified instead. Enamel coatings TT-E-489 or TT-E-1593 would then be used as topcoats.

A superior coating system would be provided by sandblasting to a near-white metal finish, SSPC-SP10, and priming with an inorganic, zinc-rich primer. The metal should then be top-coated with at least three coats of vinyl, to at least 6 mils total dry film thickness. See also previous comments on inorganic, zinc-rich coatings under Items Requiring Immediate Attention, 11225-13, 8.14.

13602-17 10.0 Factory Color Finish:

Add to the specification: "All metal edges of the siding or sheet-metal roofing shall be coated at the factory. If the siding or roofing sheet metal is cut during installation, be sure all exposed edges are patched properly using the manufacturer's recommended coating."

13602-18 10.1 Factory Tests:

When construction is to be in locations with frequently high winds and blowing sand, it may be beneficial to require that the coating meet an abrasion resistance test: "When subjected to the falling sand test in accordance

with ASTM D 968, the coating system shall withstand a minimum of 3.57 cu ft of sand before the appearance of base metal."

15116 WELDING, MECHANICAL

Stainless steel welding is critical to proper workmanship. Recent experience in construction⁷ welding of stainless steel (USAF Arnold Engineering Center in Tennessee) has indicated extensive problems, even when correct specifications were given (AWS D10.4-79). Make sure the contractor follows specifications carefully and emphasize avoiding the following common mistakes in workmanship:

1. Weld spatter.
2. Embedded material such as iron chips and rust.
3. Entrapment of slag in weld metal.
4. Colored markings in welds.
5. Splashing of paint near surfaces.

15140 SEWAGE LIFT STATION

15140-3 3.1 Miscellaneous Metal:

Bolts and nuts shall be cold-worked type 316 stainless steel or precipitation-hardened grade ASTM 637, such as Armco 17-4 PH or equal.

15140-6 11.0 Pump Construction:

Most sewage can be handled by pumps assembled from ductile-iron shells and internal components which are rubber (e.g., neoprene) coated/lined. The rubber linings, however, are susceptible to cutting damage by items such as can lids. This can lead to premature pump failure by corrosion.

Heavy-duty pumps should be assembled using the materials listed in Table 2. The bottoms of the strainers should be factory-fitted with sacrificial zinc anodes to minimize any crevice corrosion on the outside surfaces of the pumps when they are submerged.

⁷L. Gilbert, Corrosion of Stainless Steel Construction at Arnold Engineering Development Center (AEDC), Technical Report No. DRSAR 81-E-102 (U.S. Army Armament Material Readiness Command, 1982).

Table 2

Material for Fabricating Heavy Duty Pumps*

<u>Component</u>	<u>Material</u>
Stator housing	Type 316 stainless steel
Pump housing	Type 316 stainless steel
Junction box cover	Type 316 stainless steel
Impeller	Type 316 stainless steel
Shaft	Types 420 and 431 stainless steels
Cooling jacket	Type 304 stainless steel
Wear rings	
Rotating	Type 316 stainless steel
Stationary	Nitrile rubber (40 degree IRH)
O-Rings	Nitrile rubber (70 degree IRH)
Grommets	Chloraprene rubber (60 degree IRH)
Strainers	Type 316 stainless steel

*Source: Flygt Product Education Manual (Flygt Corp., Norwalk, CT).

**IRH = International Rubber Hardness as defined in ASTM Annual Book of Standards.

Materials which should be considered for the assembly of sludge pumps include those listed in Table 3. If these pumps will be submerged, they should be cathodically protected using zinc anodes.

15140-6 11.1.1 Castings:

Instead of "cast iron or semisteel," substitute one of the materials suggested in 15140-6 11.0 above.

15140-7 11.1.2 Impellers:

Instead of "cast iron or semisteel," substitute one of the materials suggested in 15140-6 11.0 above.

Table 3

Materials for Assembling Sludge Pumps

<u>Component</u>	<u>Material</u>
Impeller	Ni-hard
Casing	Ni-hard
Casing liner	Ni-hard
Shaft sleeve	Type 316 stainless steel
Stuffing box	Type 316 stainless steel

15140-7 11.2.2 Shafts:

Instead of "cast iron or semisteel," substitute one of the materials suggested in 15140-6 11.0 above.

15201 WATER LINES

15201-11 4.5 Valves:

Use nickel aluminum bronze when the surface is exposed to saltwater.

15201-13 4.9.1 Service Clamps:

Service clamps and all associated hardware shall be copper-based alloy, electrically isolated from the main pipeline to prevent dissimilar metal contact. The main pipe and service pipe shall be electrically bonded to ensure cathodic protection. The service clamp and associated hardware shall be coated with MIL-C-18480.

15201-14 5.2 Handling:

Add to this section that all bituminous or plastic-coated (e.g., polyethylene, epoxy) piping, valves, or accessories shall be protected from prolonged exposure to sunlight. Even after being placed, but before actual burial, these materials shall be kept covered.

15201-15 5.4.1 Water Lines:

Where nonferrous metallic piping crosses ferrous piping with a separation of less than 2.6 ft a 6 ft x 6 ft felt insulating blanket shall be placed between the pipes.

15201-17 5.5.2 Cast Iron Pipe and Ductile Iron Pipe:

Cast iron and ductile iron joints shall be bonded electrically to insure electrical continuity.

15201-19 5.6.5 Pipe Passing Through Walls:

Line 5 should be changed to read "filled with appropriate mastic sealant/cement."

15201-22 5.7.5.3 Fittings and Specials:

Bolts and nuts shall be cold-worked type 316 stainless steel.

15240 ELEVATED STEEL WATER TANKS

15240-8 9.1 Exterior Surfaces:

A vinyl coating system is excellent for very aggressive exposures. In the future, consider specifying the Corps of Engineers' vinyl formulation coatings as found in Civil Works Guide Specification CW 09940, Painting Hydraulic Structures and Appurtenant Works, August 1981. An international orange vinyl is not listed in this guide specification; however, the formulation in Table 4 can be used.

The pigment and caking control agent shall be dispersed with a pebble mill or other approved method to produce a grind (ASTM D 1210) of fineness no less than 6. Materials not shown in the formula will not be permitted. The finished paint shall reasonably approximate color number 12197 of Federal Standard 595. Samples of the finished paint submitted for approval shall include all ingredients, together with trade designations and producers.

All ingredients of this formula except the pigment and caking control agent are the same as those used in vinyl formulation V-766e and are described in Guide Specification CW-09940, August 1981. The specifications for these two ingredients are:

1. Molybdate orange pigment shall conform to ASTM D 2218 and shall be of the appropriate shade.

2. The caking control agent shall be either Bentone 11-N produced by NL Industries or M-P-A produced by the Baker Castor Oil Co. (M-P-A 60 toluene or M-P-A 60 xylene may be used by increasing the amount shown in the formula from 1.0 percent to 1.6 percent and by decreasing the amount of toluene by 0.6 percent.)

All areas to be coated with this paint MUST be primed first with at least two sprays of an adhering vinyl such as V-766.

Table 4

International Orange Vinyl Paint

<u>Ingredient</u>	<u>Parts by Weight</u>
Vinyl resin type 3	17.0
Diisodecyl phthalate	3.5
Molybdate orange pigment	14.0
Caking control agent	1.0
Toluene	22.5
Methyl isobutyl ketone	21.0
Methyl isoamyl ketone	<u>21.0</u>
	100.0

15240-8 9.2 Interior Tank Surfaces:

The current system is acceptable. However, some other coating systems are better and more convenient. Pretreatment vinyl coating systems are no longer specified for Corps of Engineers' Civil Works structures except in unusual circumstances. One major problem with the MIL-P-15328 pretreatment is that it has a potlife of 8 hours after the acid component has been added; the coating looks the same after 8 hours, but will not adhere to the surface. If the painter doesn't realize this, forgets, or just doesn't heed the warning, catastrophic failures are imminent.

One recommended replacement is an epoxy coating system, Inside Paint System No. 1, as given in AWWA D-102-78. This system lists three choices of materials:

1. Paint 1--a three-coat system in accordance with MIL-P-24441.
2. Paint 2--a two-coat system in accordance with MIL-C-4556.
3. Paint 3--an equivalent system for which the manufacturer has provided documentation consisting of test data, service history, and toxicological information.

USA-CERL has worked with the two military specification epoxies and found them to give excellent performance in long-term water immersion. Both coating systems are available as standard shelf products from various manufacturers (see their Qualified Products lists).

Alternatives would be one of the vinyl paint systems from the Corps of Engineers Civil Works Guide Specification for painting, CW-09940. System numbers 3, 4, or 5 may be specified for steel potable water storage tanks. Of the three, system 3 with aluminum topcoats is the most impermeable; the other two are more abrasion-resistant. (Abrasion resistance in a water tank is important in areas where floating ice can form--probably not very significant in the Middle East.) The required surface preparation, coating thickness, and paint formulations for these systems is in CW-09940. The Corps of Engineers' vinyl systems are at least equal, if not superior, to the vinyl systems listed in AWWA's Inside Paint Systems Nos. 2 and 4.

Consider the following facts when choosing between epoxy or vinyl systems: an epoxy system probably is somewhat cheaper to apply, but a properly applied vinyl system should have a longer lifetime. For highly corrosive environments in which a vinyl system would be applied on the outside, a vinyl system would be the logical choice on the inside, as well.

Regarding surface preparation requirements: if the specified coating system is not replaced with one of the recommended systems, one important deficiency should be noted. Even though taken directly from Guide Specification CE-505, the surface preparation requirements are insufficient for water immersion. Applying a coating system over commercial-grade blast cleaning (SSPC-SP No. 6) is not acceptable. Also, a pickling process of cleaning (SSPC-SP No. 8) is not the most desirable since the blasting profile increases the surface area and gives the coating something to "bite into." NO MATTER

WHAT COATING IS USED, IF THE SYSTEM IS FOR WATER IMMERSION, SPECIFY A WHITE-METAL GRADE OF BLAST CLEANING. The requirements in SSPC-SP No. 10 (1 Nov 82 revision) are considered acceptable, with SSPC-SP No. 5 even better. The requirement for a near-white-metal blast cleaning on pages 9-45 and 9-46 of the Civil Works Guide Specification CW-009940, August 1981, could also be used.

The above information applies to all steel water-storage tanks, whether elevated, standpipe, or ground reservoir.

15263 HYPOCHLORITE FEEDING SYSTEMS

15263-4 6.5 Chlorine Solution Lines:

A pressure regulator and a noncorrosive screen (polyvinyl chloride) shall be provided.

15263-5 6.7.2 Copper Tubing:

Copper tubing shall be reamed to insure flare fit.

15303 FORCE MAINS; SEWER

15303-4 6.0 Handling:

Add to this section that all bituminous or plastic-coated (e.g., polyethylene, epoxy) piping, valves, or accessories shall be protected from prolonged exposure to sunlight. Even after being placed, but before actual burial, these materials shall be kept covered.

15401 PLUMBING, GENERAL PURPOSE

15401-15 9.0 Flashings (Pipes Passing Through Roof or Floor):

If copper is used in flashing, the flashing should not be connected to aluminum or positioned so that water run-off could contact aluminum. If contact is made, water will pick up copper ions and deposit them on aluminum, causing rapid pitting of the aluminum.

15401-17 12.1.3 Floor Sink:

A copper sediment bucket should be used since it would resist chloride pitting attack.

15401-23 24.1.1 Pipes Passing Through Roof:

If copper is used in flashing, make sure the flashing is not connected to aluminum or positioned so that water run-off could contact aluminum. If contact is made, water will pick up copper ions and deposit them on aluminum, causing rapid pitting of the aluminum. Refer to section 07600, Sheet Metalwork, General, to review these requirements as given under paragraph 7, Protection of Aluminum.

15401-28 27.2.1 Shop Painting:

TT-P-57 is a discontinued specification. The cancellation cites TT-P-1757 as a replacement; however, this specification is not considered an exact equal for TT-P-57. Also, TT-P-645 as an alternative needs very good surface preparation (at least commercial grade, SSPC-SP6) for optimal performance.

15401-28 27.2.2 Field Painting:

This section states that the specifications on field painting of tank interiors is given in the section Painting, General (09900). However, the requirements in this section do not cover tank interiors for immersion service. The tank should be coated as per the requirements in Elevated Steel Water Tanks (15240).

15605 FUELING SYSTEM FOR MOTOR VEHICLES, SERVICE STATION TYPE

15605-7 9.0 Preparation of Tank Interiors:

The specification calls for tank interiors to be coated with a temporary, water-soluble rust inhibitor. However, no details are given as to what this soluble rust inhibitor should be or how it is to be removed before the tank is filled. A simpler system would be to clean rust from the tanks and then wipe them down with an oil compatible with the fuel to be stored therein. To prevent corrosion on tank bottoms due to water accumulation, a zinc-ribbon-type cathodic protection anode shall be fitted to extend the full length of the tank bottom.

15605-8 13.1 Shop Preparation (Exterior Preparation and Painting):

When using an inorganic, zinc-rich primer, a commercial grade of blast cleaning is considered to be minimum. A blast cleaning to a near-white grade, SSPC-SP10, would ensure better coating performance.

The meaning of the sentence "Surface irregularities from blasting shall be approximately 30 percent of dry mil thickness and shall not exceed 1.0 mil" is not clear. Moreover, the sentence should be eliminated because it is not needed.

15605-9 13.4 Finish Coat:

As stated, the finish coating for this tank is not covered adequately in Painting, General (09900). Inorganic zinc-rich paints are suitable coatings, but it is often hard to make finish coats adhere. Therefore, only a proven compatible system should be used. Both the primer and topcoat should be from the same manufacturer.

An alternative to the above system is Corps of Engineers' E-303 zinc-rich primer and V-766 white vinyl topcoats as given in Corps Guide Specification CW-09940, August 1981. Surface preparation should be near-white metal, SSPC-SP10.

15609 POL AND DIESEL STORAGE TANKS, CONTROLS, AND PIPING

General comments. If any aboveground steel pipe in the POL or diesel storage system is exposed to the weather, it should be coated with an inorganic, zinc-rich primer coating with vinyl topcoats. See additional comments under 15605-9, 13.4 above.

15609-12 10.1.2 Operating Storage Tanks:

After the tank is pressure-tested with saltwater and then drained, it should be rinsed with fresh water to remove any salt residue before sand-blasting and coating.

15609-13 10.3.1 Conditions:

The Permatex material given in this section is not on the latest Qualified Products List dated 10 June 1980. If this material has not received other official qualification, reference to this coating material should be deleted. Reference should instead be given to the Qualified Products List for the MIL-C-4556 epoxy coating.

15609-14 10.3.3.1 Impermeability:

After the final coat, holidays shall be tested for using a 90-V pinhole detector; all holidays shall be ground out and recoated.

15609-14 10.3.3.3 Temperature Dependence:

High temperature cautions are not stated. However, caution should be exercised to ensure the coating is not applied when the temperature of the air, the receiving surfaces, or both is high enough to cause blistering, pinholing, or other defects in the cured film.

15609-15 10.3.4.2 Pretreatment:

Regarding the second line from the top of the page, "Only steel grain shall be used for blasting on airports," this requirement would not seem to make much difference for a desert location with blowing sand. Also, "grit" and "abrasive" are more common terms than "grain."

The sentence beginning on line 9 should read, "Size and hardness of the abrasive material shall be selected to provide for an average surface roughness (profile) of about 2 mils. Because of poor agreement among different methods of measuring surface profile, a particular method or instrument should be specified. Two such instruments are: (1) Surface Profile Comparator Kit and (2) Elcometer Surface Profile Gage. These devices are available from several different suppliers of inspection equipment for the paint industry.

Defects with a depth less than 25 percent of the nominal wall thickness shall be mechanically treated and filled with a suitable filler material. Defects with a depth greater than this value shall be treated mechanically and repaired by welding using a compatible stick electrode.

Note: The maximum allowable number of defects with depth greater than 25 percent of the nominal wall thickness should be specified.

This section states that all sandblasting steel must be topcoated within 5 hours. Add to the end of this sentence, "but in any event, before any contamination or deterioration of the prepared surface."

15609-16 10.3.4.3 Safety Measures:

Section e should read, "In addition, the air in enclosed spaces shall be safe at all times from fire and explosion hazards as determined by a calibrated explosimeter or organic vapor analyzer."

15609-21 10.3.7 Equipment Outfitting:

In Section h, "ex-meter" should read "explosimeter."

15609-27 13.3 Isolation Valve Pit:

Specify 6061 or 6063 aluminum in T6 condition. Do not use the 2000 or 7000 series; these are subject to stress cracking or intergranular corrosion in a saltwater environment.

15609-27 13.4 Grounding Pits:

Replace the single piece cast aluminum alloy pit cover with a bronze pit cover to prevent dissimilar metal contact.

15609-39 23.1 Cleaning of Surfaces to be Coated:

The blast cleaning should be in accordance with SSPC-SP10, near-white metal. Commercial blast cleaning is only marginally effective, considering the exposures and coatings to which the pipe will be subjected.

15609-40 23.2.1, 23.2.2, 23.3 and 23.3.1 Tape Wrapping:

A simpler method of specifying a protective tape wrap is to specify hot-applied coal-tar tape meeting AWWA C-203.

Note: The hot-applied coal-tar tape meeting AWWA C-203 is considered better than cold-applied protective tapes. However, the hot-applied tape's performance is very dependent on proper application. If the quality of labor available is a concern, the next best choice is a prefabricated, cold-applied tape, 50 mils thick, meeting AWWA C-209. Tapecoat CT-10/40W, from the Tapecoat Company, Evanston, IL, meets these requirements. Tape wrap should be applied with care because high winds can blow sand onto primer, embedding sand between the tape and pipe.

15609-43 25.1.5 Insulating Flanges:

In line 6, MIL-C-18480 coal-tar enamel could be specified for the primer and enamel coating referenced. In line 7, specify L-T-1512, type I for the organic plastic tape.

15653 AIR-CONDITIONING SYSTEM (UNITARY TYPE)

15653-15 7.3.1 Direct Expansion Coils:

The direct expansion coils for air-conditioner systems (other than standard through the window or wall type room air-conditioners) which draw outside air across the expansion (cooling) coils and which are located within 1 mi of an open body of saltwater or similar corrosive atmosphere shall be constructed of seamless copper tubes and copper fins mechanically bonded or soldered to the tubes. Direct expansion coils constructed of aluminum fins on copper tubes are acceptable for systems that use only recirculated room air across the coils.

15653-17 9. Condensers:

Ideally, the condensing unit of roof- or foundation-mounted air-conditioning systems should be located such that it is shielded from the prevailing winds. Wind can cause salt and debris (moisture traps) to collect on the condenser coils, thereby promoting corrosion. If the unit cannot be located out of the prevailing winds, a wall should be built around two sides. This wall shall be constructed with at least the minimum clearance recommended by the air-conditioner's manufacturer. (Unit efficiency could be reduced greatly if the wall is placed too close.)

15653-18 9.1.1 Condenser Coil:

Aluminum fins on aluminum tubes, such as those manufactured by Carrier Corporation, should be specified for the condenser coils in through-the-window or wall-type room air-conditioners. Units with aluminum tube/aluminum fin construction will provide longer service lifetimes by eliminating the galvanic corrosion associated with copper tube/aluminum fin combinations.

15653-31 15.11.1 Pipes Passing Through Waterproofing Membranes:

The choice of flashing material will depend on the location and type of surrounding materials. See previous comments under Items to Consider for Future Construction and Maintenance Needs, 15401-15 9.0.

15801 VENTILATING SYSTEM, MECHANICAL

15801-6 3.7.3 Frames for Screens:

Aluminum screen shall be used with aluminum frames only. Aluminum and stainless steel should not be in contact in order to avoid galvanic corrosion.

15801-20 13.1, 13.2 Hoods Over Cooking Equipment; Hoods Over Dishwashing Machines:

Type 304 stainless steel should be used for all interior hoods.

15801-21 15.1 Factory Coating:

In line 5, "504 hours" should read "500 hours."

16212 GENERATING UNITS, DIESEL-ELECTRIC

16212-23 12.1.1 Cleaning and Painting of Day Tank:

The sentence starting at line 3 is not acceptable. Sandblasting will not remove all oil or grease; solvent must be used to clean the surface if oil and grease are present.

16212-32 15.0 Exhaust System:

Diesel engine exhaust stacks will be externally sandblasted and coated with heat-resistant paint meeting MIL-P-14105. This coating is serviceable up to 1400°F.

16402 ELECTRICAL WORK, INTERIOR

16402-9 3.6.6.3 Coal-Tar System:

The MIL-P-15147 coal-tar enamel specified in this section has been canceled; coal-tar enamel meeting AWWA C-203 should be specified instead. In most cases, coal-tar epoxy (Corps of Engineers' specification C-200) is also an acceptable replacement.

16402-13 8.2.1 Installing Below Slab-on-Grade or In-Ground:

Comment on the last sentence: galvanized and coated steel conduit would provide better corrosion protection than just coated steel conduit, especially if the conduit is to be buried in soil.

16402-22 18.0 Motors:

Motors for outdoor use shall have a factory-applied, rust-inhibitive finish.

16460 TRANSFORMERS

General comment. Transformers for exterior exposure should have a factory-applied, rust-inhibitive finish suitable for warm, coastal environments.

16532 ELECTRIC DISTRIBUTION AND STREET LIGHTING SYSTEM; UNDERGROUND

General comment. Transformers for exterior exposure should have a factory-applied, rust-inhibitive finish suitable for warm, coastal environments.

16532-8 3.5 Corrosion Prevention:

Specify a rust-inhibitive primer coating instead of a rust-inhibitive treatment.

In lines 14 and 15, a single layer of pressure-sensitive plastic tape is inadequate for this environment. Hot-applied coal-tar tape or factory epoxy-coated galvanized conduits should be used. See previous comments under 01003-13, 6.7.

All exterior exposed galvanized steel shall be coated as specified previously. All exterior exposed aluminum should be anodized and not used in conjunction with galvanized steel.

16532-30 16.0 Lighting Poles:

Aluminized steel should be used for all accessories. If this is not obtainable, cadmium-plated steel should be used.

16560 AIRFIELD LIGHTING

16560-12 5.12 Installation of Obstruction Light on Elevated Water Tank:

All exterior exposed galvanized steel should be painted or plastic-coated. Exterior fittings shall be specified.

16640 CATHODIC PROTECTION SYSTEM FOR BURIED UTILITIES

16640-2 3.1.1 Anode Material (Impressed Current Anodes):

General comment. All underground metallic piping shall be coated and cathodically protected. All unwelded joints in piping shall be bonded for electrical continuity. Revised (Nov 1982) CEGS-16650, Cathodic Protection System (Impressed Current), should be used. Furthermore, ceramic ferrite anodes with performance equal to or better than silicon-iron can be used in impressed-current cathodic protection systems. APS Material Inc., 153 Walbrook Avenue, Dayton, OH, is the exclusive, licensed supplier of the ceramic anode to the DA.

16640-4 3.5.1 Cathodic Protection Rectifier:

Exterior exposed rectifier cabinets shall be anodized aluminum or type 304 stainless steel.

16640-7 7.2.1 Anode Placement, General:

The specification allows approximately 2 gal of water to be poured into the hole. This is not recommended, however, as it may produce an air gap when the water dries, increasing the electrolyte-to-anode resistance.

Sacrificial anodes shall be a minimum of 3 ft from the protected structure.

Leadwire connections should be strengthened before burial by taping the wires back 2 or 3 in. from the the weld. This will reduce stress on the lead-wire weld during burial.

16640-8 9.1 Stations:

Test stations should be elevated above ground level for ease in location.

16640-12 14.0 Insufficient Protection:

See comments under Items to be Considered in Future Construction and Maintenance Needs, 16640-2, 3.1.1.

16641 CATHODIC PROTECTION SYSTEM FOR STEEL WATER TANKS

16641-5 4.10 Cabinet:

Rectifier cabinets shall be anodized aluminum or type 304 stainless steel.

16723 FIRE PROTECTION AND ALARM SYSTEM

16723-3 5.0 Alarm Bells:

The the exterior alarm bell shall be a copper-based alloy.

Drawings

OM-215 Emergency Water Storage Tank: (XM-14)

The drawing specifies that a protective coating be applied on all inside surfaces. However, no specification for such coating is given on the drawing or listed in the specifications. If the concrete tank is constructed properly, a coating normally would not be needed. If a coating is required, use either a chlorinated rubber coating, TT-P-95, or any epoxy polyamide coating, MIL-P-24441.

OM-279 POL Storage Tank: (S-14)

The welding details for the fillet weld on the ladder bracket shown in Detail J should be added to the drawing.

OM-292 through OM-316 POL Storage and Distribution: (M-4 thru M-27)

More pipe weld details should be shown in the drawings.

OM-328 POL Storage (Cathodic Protection Details): (E-8)

This drawing shows coal-tar epoxy being used to seal the thermit weld and is not consistent with the specifications. The specifications should be followed; that is, use mastic sealant and plastic shield rather than just the coal-tar epoxy.

OM-387/OM-404 Dormitories: (A-4/A-2)

For the air-conditioning opening detail, it is specified that the protective cover (galvanized steel), including miscellaneous steel, is to be painted to match the stucco. Refer to section 09900, Painting, General, in the specifications; use of the wrong coatings over galvanized steel can lead to rapid coating failure.

OM-403 Munitions Maintenance Facility: (A-1)

The color for the steel guardposts should be specified on the drawing.

OM-406 Munitions Maintenance Facility: (S-1)

See above comments about drawings OM-387/OM-404.

OM-449 Aircraft Shelter--Wheel Module Details: (S-17)

Detail C. The spring stay requires weld symbols.

Detail E. The cross section view requires weld symbols on the wheel brackets.

OM-454 Aircraft Shelter: (S-22)

Show that the concrete anchor bolts are to be attached using shielded metal arc or stud welding.

OM-455 Aircraft Shelter: (S-23)

Care should be taken to avoid shrinkage in the welds of the cover plates.

Section B. All fillet welds need detailed weld symbols.

Section C. There is an inconsistency between the welding symbol and the drawing for both welds connecting the .75-in. plate on the left.

OM-461 Aircraft Shelter: (M-2)

Weld details should be added to the drawing entitled "Detail in the Air Intake Pipe."

For future construction, galvanized steel pipe should be specified. Ideally, the inside of the pipe should also be galvanized. After the pipe is welded to the corrugated arch, the weld areas must be regalvanized or repaired with DOD-P-21035 galvanized repair paint. All galvanized steel to be exposed to the weather should be coated.

Suggestions for Maintenance or Rehabilitation of Deteriorating Items or Structures Already in Place: Specifications

Some items or structures may show signs of deterioration more rapidly than expected, but are too costly to replace immediately with materials that should have been used originally. Maintenance criteria are available for items falling into this category. To eliminate this situation in future construction, materials should be selected as described in the preceding sections.

02711 FENCE, CHAIN-LINK

When non-vinyl-covered posts and rails show signs of corrosion, they should be coated with one of the following systems:

1. One or two coats of zinc-dust primer coating (TT-P-641).
2. A primer coat of TT-P-641 with two topcoats of exterior alkyd enamel. (The enamel could be pigmented to match the green fence fabric.)
3. One or two coats of zinc-dust chlorinated rubber coating (TT-P-1046).

11225 WATER DESAL PLANT

11225-15 8.18.6 Painting:

If the system on the boiler and surrounding steel starts to fail because of extremely high temperatures, all paint must be removed by sandblasting to a near-white metal grade (SSPC-SP10) and coated with one of the following materials: for interior or mild exterior exposure, use TT-E-496, enamel, heat-resisting (400°F), or TT-P-28, paint, aluminum, heat-resisting (1200°F). For exterior, corrosive exposures, use MIL-P-14105, paint, heat-resisting (for steel surfaces) (1400°F).

5 DETAILED REVIEW COMMENTS FOR FY83 PROGRAM

Items Requiring Immediate Attention

Certain items requiring immediate attention were noted during the review. "Immediate attention" may mean that immediate correction or changes should be performed to avert catastrophic failure or eliminate a potential safety hazard; it may also mean careful monitoring of a material's performance when used to make a particular item or structure when information on that material is questionable or unknown. Items addressed here should be considered for all future construction at the Oman site and all sites with similar environmental conditions.

Specifications

02711 FENCE, CHAIN-LINK

See comments on the same section under Items Requiring Immediate Attention in the FY81 and 82 Program.

05500 MISCELLANEOUS METAL

See comments on the same section under Items Requiring Immediate Attention in the FY81 and 82 Program.

07600 SHEET METALWORK, GENERAL

See comments on the same section under Items Requiring Immediate Attention in the FY81 and 82 Program.

09900 PAINTING, GENERAL

See comments on the same section under Items Requiring Immediate Attention in the FY81 and 82 Program.

15201 WATER LINES

See comments on the same section under Items Requiring Immediate Attention in the FY81 and 82 Program with the following modifications:

15201-5 2.2 Piping for Water Lines:

No provision for the saltwater distribution has been stated.

15201-11 4.5.3 Valve Encasement:

See section 15201-12 4.5.5 under Items Requiring Immediate Attention in the FY81 and 82 Program.

15401 PLUMBING, GENERAL PURPOSE

15401-20 13.1 Water Pipe:

See section 15201-17 14.1 under Items Requiring Immediate Attention in the FY81 and 82 Program.

15401-23 13.5 Protective Coatings for Pipe and Fittings:

See section 15201-20 14.6 under Items Requiring Immediate Attention in the FY81 and 82 Program.

15609 POL STORAGE TANKS, CONTROLS, AND PIPING

15609-26 16.0 Protective Coatings:

See section 15201-20 14.6 under Items Requiring Immediate Attention in the FY81 and 82 Program.

Drawings

OM-1086 Power Check Pads: (C-31)

All exterior exposed galvanized steel should be coated.

OM-1253 Air-Conditioner Protective Cover: (SM-1)

All exterior exposed galvanized steel should be coated.

Items to Consider for Future Construction and Maintenance Needs

Comments and recommendations in this section should be considered for all future construction at this site and all sites with similar environmental conditions. These comments and recommendations also should be used as a reference for maintenance criteria in case existing materials fail.

Resurfacing

02610 RESURFACING OF RIGID PAVEMENTS WITH THIN BONDED RIGID OVERLAYS

See comments on the same section under Items to Be Considered in Future Construction in the FY81 and 82 Program.

02611 CONCRETE PAVEMENT FOR AIRFIELDS

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

02618 PAVEMENT/MARKINGS (AIRFIELDS AND ROADS)

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

02711 FENCE, CHAIN-LINK

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

03316 CONCRETE (FOR BUILDING CONSTRUCTION)

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

05120 STRUCTURAL STEEL

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

05500 MISCELLANEOUS METAL

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

05500-10,11, 20.0,21.0 Safety Chains, Guard Rails, and Safety Nosings:

See comments in section 05500-11 22.0, 23.0 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

05500-12 25.0 Tie Rods and Turnbuckle Assemblies

All tie rod and turnbuckle assemblies should be galvanized steel.

07112 ELASTOMERIC WATERPROOFING

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

07600 SHEET METALWORK, GENERAL

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

07951 CALKING AND SEALANTS

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

08105 STEEL DOOR AND FRAMES

08105-2 4.4 Thresholds:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program. Delete comment on misspelling of aluminum.

08105-3 5.0 Installation:

See comments in section 08105-5 7.0 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

08300 MISCELLANEOUS DOORS

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

09800 CONCRETE FLOOR SPECIAL COATING

09800-3 4.2.4.1 Acid Etchant:

Tests with pH paper should be done to determine that all acid and alkali (neutralizer) solutions have been removed.

09900 PAINTING, GENERAL

For future reference, a definition of a rust-inhibitive coating should be added to the specifications: "Rust-inhibitive coating--Coating used to prevent metal corrosion; more particularly, one specially formulated to prevent the rusting of iron, steel, and other metals."

09900-o 6.0 Quality Assurance Provisions:

Red-lead primer, TT-P-86, should be specified for oil-based (enamel) paint systems used to protect atmospheric-exposed mild steel. However the lead content of TT-P-86 far exceeds the 0.06 percent maximum lead content as required by U.S. Public Law 94-317. Lead-containing paints are prohibited at

child accessible interior and exterior areas, such as schools, nurseries, and family housing. Under normal circumstances, lead-containing paints are not a health threat for adults and, therefore, should not be restricted at facilities like those being constructed at military installations in the Middle East. Alternative non-lead-containing paints will either be more expensive due to greater material and labor costs (from the greater surface preparation needed), or will have inferior performance, especially for hot, coastal exposures. Red-lead primer has even greater value for maintenance painting.

The sentence starting at line 3 says: "When certifying a maximum of 0.5 percent lead, the Contractor shall also certify that the paint was manufactured prior to June 23, 1977." For future contracts, this statement should be deleted because the paint would be very old and of questionable quality.

In the sentence starting at line 40: Requirements for the testing procedures and reports must be detailed in the specification since Method 1031.2 in current Federal Standard 14 has been canceled with no superseding document cited.

09900-7 Quality Assurance Provisions:

In the last sentence of the first paragraph of the page, The "\$100/sample" for retesting is not considered enough. An average of \$250 to \$500 per sample is closer to current laboratory charges. However, the specification states that the cost of retesting will be deducted from the payments due the contractor, so no fixed amount actually needs to be stated. Costs will continue to vary with time and the laboratory used.

09900-7 7.0 Environment:

The following sentence should be added to this section: "Variance to the stated upper temperature limits will be approved only if it can be demonstrated that the variance will not result in inferior coating performance."

09900-8 8.7 Vinyl Paints:

General comments. Vinyl paints should perform excellently in atmospheric exposures for these types of locations. However, the current systems as given in Guide Specification CW-09940, August 1981, Hydraulic Structures and Appurtenant Works, should be specified.

09900-8 8.7.1.1.1 Formula VZ-107:

This outdated specification has been known to cause major problems in field application. Material applied satisfactorily should have no problems now; however, in the future, specify VZ-108 from the current guide specification.

09900-9 thru 12 8.7.1.1.2 Formula V-766b;

8.7.1.1.3 Formula V-102b;

8.7.1.2 Ingredient Material for Special Paint:

All of this information should be updated to conform to Guide Specification CW-09940, August 1981, as stated above.

09900-12 10.2 Concrete and Masonry Surfaces:

Concrete surfaces to be painted shall have the surface glaze, if present, removed by light blasting or by scrubbing with a 5 percent solution of phosphoric acid. The acid treatment shall be followed by rinsing the surfaces with water and allowing to dry. For interior walls and floors, sandblasting, unless specifically authorized otherwise, shall be restricted to the wet or vacuum type.

09900-13 10.5 Plaster Surfaces:

The requirement that plaster shall be allowed to age at least 30 days before painting (as per CEGS-09910, Painting, General, January 1978) should be added to future contracts. The aging process decreases surface alkalinity by reacting with carbon dioxide in the air. This, in turn, decreases the chance of paint problems caused by a too high surface alkalinity. Problems occurring because of materials already applied should be handled on a case-by-case basis.

09900-14 11.6.1 Other Masonry Coating:

The title says "Other Masonry Coating." The "Other" should be eliminated in this case as no previous masonry coating is mentioned.

09900-15 11.8 Exterior Ferrous Surfaces to Receive Vinyl Paint System:

If Corps of Engineers paint systems are going to be used, this section must be completely replaced with proper information from Guide Specification CW-09940, August 1981.

09900-16 11.10 Epoxy Coating:

The following sentence should be added to this section: "If required by the manufacturer, the pigmented epoxy resin shall be mixed with the hardener 1 hr before thinning or application."

09900-19 Painting Schedule:

First system on the page: for greater corrosion protection of non-shop-coated bare steel, specify TT-P-86, Type II, rather than a ferrous metal primer. Power tool cleaning that meets SSPC-SP3 or brush-off blast cleaning that meets SSPC-SP7 is considered minimum surface preparation for using this primer. (Type I primer is acceptable with hand-tool cleaning meeting SSPC-SP2. However, the dry time of the Type I primer is much longer than that of Type II. This may not be advantageous in windy and dusty locations.) Also, for the second and third coats, rather than specifying an exterior oil paint, specify an exterior alkyd-enamel, TT-E-489 (TT-E-529 for semigloss) or an exterior silicone alkyd enamel, TT-E-1593 (TT-E-490 for semigloss) for much greater protection of steel in such environments. (Also see comments under Items to be Considered in Future Construction and Maintenance Needs [FY81 and 82 Programs], 09900-8 4.8.)

Second system on the page: for exterior exposures, a rust-inhibiting primer should be specified as the shop-coat primer. Areas for which the shop coating has been damaged should be power-tool-cleaned as per SSPC-SP3 or brush-off blast-cleaned as per SSPC-SP7 before applying the TT-P-86, Type II primer. (These surface preparation choices are considered minimum for the Type II primer.) Also, see comments above on specifying exterior oil paint for the second and third coats.

09900-20 Painting Schedule:

Regarding the first system on the page: although the specified system should not catastrophically fail, it will not provide maximum protection. One of the following systems is recommended for exterior galvanized surfaces:

1. One or two coats (depending on exposure conditions) of zinc-dust primer coating (TT-P-641), or zinc-dust chlorinated rubber primer coating (TT-P-1046).

2. A primer coat of TT-P-641 with two topcoats of exterior alkyd enamel or silicone alkyd enamel. Also, see comments on exterior alkyd or silicone alkyd enamel under Items to be Considered in Future Construction and Maintenance Needs (FY81 and 82 Program), 09900-18, second system on the page, and 09900-8, 4.8.

3. Two coats of zinc-dust primer coating, MIL-P-26915, and two coats of aliphatic urethane topcoat, MIL-C-83286.

For added adhesion over galvanized surfaces, wash primer pretreatment DOD-P-15328 should be used.

Regarding the second system on the page: using TT-P-38 as a primer is unnecessary unless the calking compound is a bituminous material that may bleed.

Regarding the fourth system on the page, the following note should be added: "A ferrous metal primer shall be selected that is compatible with the specified alkyd enamel second and third coats."

09900-21 Painting Schedule:

Regarding the first system on the page: this section should read exactly like that for the fourth system on page 09900-20 for interior exposed ferrous surfaces. The previous comments about the fourth system on page 09900-20 also apply.

Regarding the third system on the page: for the highest degree of sanitation, the second and third coats should be epoxy polyamide, TT-C-535, Type II. TT-C-535 will give a tile-like finish. A less expensive material, but with less hardness than TT-C-535, would be TT-P-2119 latex coating for high-traffic areas in flat and eggshell finish (for interior use).

10160 METAL TOILET PARTITIONS

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

13602 METAL BUILDINGS

13602-11,12 9.1 Factory Tests (Factory Color Finish):

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15116 WELDING, MECHANICAL

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15201 WATER LINES

15201-5 2.2 Piping for Water Lines:

No provision for the saltwater distribution has been stated.

15201-12 4.8.1 Service Clamps:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15201-13 5.2 Handling:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15201-18 5.6.5 Pipe Passing Through Walls:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15201-20 5.7.5.3 Fittings and Specials:

See section 15201-22 5.7.7.3 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15401 PLUMBING, GENERAL PURPOSE

15401-18 7.2.3 Glass Pipe:

The grade of stainless steel should be specified.

15401-18 9.0 Flashings:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15401-24 20.1 Electric Water Heater:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15401-26 24.1.1 Pipes Passing Through Roof:

See section 16401-23 24.1.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15401-32 27.2.1 Shop Painting:

See section 15401-28 27.2.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15401-32 27.2.2 Field Painting:

See section 15401-28 27.2.2 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609 POL STORAGE TANKS, CONTROLS AND PIPING

15609-9 10.1 Operating Storage Tanks:

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-9,10 10.1.2 Construction:

Specify that the water must be drained within 7 calendar days after filling.

15609-10 10.1.3 Corrosion Protection:

Seawater shall not be retained in the tank longer than 7 calendar days.

15609-10 10.2.1 Conditions:

See section 15609-13 10.3.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-11 10.2.3.1 Impermeability

See section 15609-14 10.3.3.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-11 10.2.3.3 Temperature Dependence:

See section 15609-14 10.3.3.3 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-12 10.2.4.2 Pretreatment:

See section 15609-15 10.3.4.2 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-13 10.2.4.3 Safety Measures:

See section 15609-16 10.3.4.3 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-18 10.2.7 Equipment Outfitting:

See section 15609-21 10.3.7 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-27 16.2.1, 16.2.2, 16.3, 16.3.1 Tape Wrappings:

See sections 15609-40 23.2.1, 23.2.2, 23.3, 23.3.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15609-30 18.1.5 Insulating Flanges:

See section 15609-43 25.1.5 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15653 AIR-CONDITIONING SYSTEM (UNITARY TYPE)

15653-6 7.1.2 Direct Expansion Coils:

See section 15653-15 7.3.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15801 VENTILATING SYSTEM, MECHANICAL

15801-5 3.6.2 Frames for Screens:

See section 15801-6 3.7.3 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

15801-17 13.1 Factory Coating:

See section 15801-21 15.1 under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

16402 ELECTRICAL WORK, INTERIOR

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

16532 ELECTRICAL DISTRIBUTION AND STREET-LIGHTING SYSTEM; UNDERGROUND

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

16560 AIRFIELD LIGHTING

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

16640 CATHODIC PROTECTION SYSTEM FOR BURIED UTILITIES

See comments on the same section under Items to Consider for Future Construction and Maintenance Needs in the FY81 and 82 Program.

Drawings

OM-1080 Site Work Sections: (C-25)

The color for the steel guard posts should be specified in the drawing.

OM-1139 POL Storage Tank: (S-4)

Detail B needs the joint welding details for joining the section at the floor and wall plates.

OM-1150 POL Storage Tank: (S-15)

Weld symbols should be added to the details.

OM-1151 POL Storage Tank: (S-16)

Weld symbols should be added to detail N or P.

OM-1157 through OM-1170 POL Storage Tanks: (M-1 thru M-14)

More welding details should be on the tanks, connections, and piping represented by these drawings.

OM-1191 POL Storage Tank (Cathodic Protection Details): (E-17)

See comments on drawing OM-328 under Items to Consider for Future Construction and Maintenance Needs in FY81 and 82 Program.

Suggestions for the Maintenance or Rehabilitation of Deteriorating Items or Structures Already in Place: Specifications

Some items or structures may show signs of deterioration much sooner than desired but are too costly to replace immediately with the materials that should have been used for original construction. Maintenance criteria are available for items falling into this category. To eliminate this problem in future construction, materials should be selected as suggested in the preceding sections.

02711 FENCE, CHAIN-LINK

See comments on the same section under Suggestions for the Maintenance or Rehabilitation of Deteriorating Items or Structures Already in Place in FY81 and 82 Program.

6 CONCLUSION

Specifications and drawings for U.S. Military Construction at Masirah Island, Oman have been reviewed for conformance with methods best suited to corrosion mitigation in these environments. Requirements not providing optimal protection for facilities in these corrosive atmospheres have been modified based on corrosion mitigation techniques and lessons learned from previous Corps construction experience in Saudi Arabia.

METRIC CONVERSIONS

1 oz	=	28.3 g
1 gal	=	3.785 L
1 mil	=	.0254 mm
1 in.	=	2.54 cm
1 ft	=	.305 m
1 mi	=	1.61 km
1 sq ft	=	.092 m ²
1 cu ft	=	.028 m ³
°F	=	(°C x 9/5) + 32

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